

An Analysis of Economic Effects of Expressways in Korea

In-chul Bae

Chief Researcher, Business Administration Research Team
Expressway & Transportation Research Institute, Korea Expressway Corporation
50-5, SanCheok, Dongtan, Hwaseong City, Gyeonggi-do, Korea (Zip : 445-812)
Telephone : +82-31-371-3422
Fax. : +82-31-371-3424
E-mail : bdkbsb@hanmail.net

Jai-soo Kang

Executive Committee Member, World Road Association (PIARC)
Executive Managing Director for Engineer, Korea Expressway Corporation
430, Daewang, Pangyoro, Sujeong-gu, Seongnam-si, Gyeonggi-do, Korea
Telephone : +82-31-779-4207
E-mail : kjs2107@ex.co.kr

June 2009

ABSTRACT

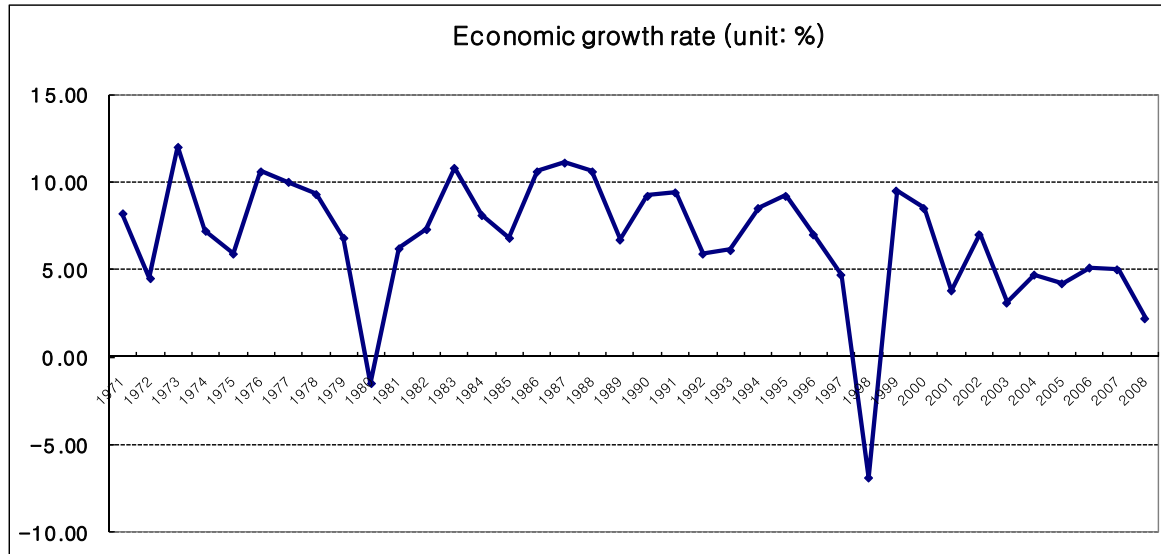
In Korea, the public investment on social infrastructure has been a key policy instrument to prime the pump to improve the economy whenever its industrial output growth and private consumption appear to slow down. Over the last decade, Korean economy has experienced a sharp downfall owing to the economic crisis in the late 1990s. The fact that total amount of SOC investment has been steadily increased since the economic crisis of 1997 explains Korean economy's making a rapid recovery. As stated in the textbook of the economics, the SOC investment expansion could be used as a pump priming policy and every government in the world has actually resorted to it. But the link between investing in road (especially expressway)

capital and productivity has not been systematically analyzed.

In this paper we analyze how the construction or investment on the roads (roads in general/expressways) has contributed to Korean economy. We adopt the method of ‘an inter-industry analysis’ in order to estimate the various effects designated by the econometric coefficients. We use the data of seven Korean Input-Output (IO) Tables reported every five years. Through the analysis, we show that the contribution of the expressway capital, representative of the road investment to TFP growth is positive in principal industries, and its economic impact has been very deep and broad compared to the OECD countries.

1. Introduction

After twenty five years of high growth (average 7.8% during 1971-97), Korean economy has experienced a sharp downfall during the economic crisis in the late 1990s, which has been adjusted to average 4.4% of growth afterwards. Further, as a result of the recent global financial crisis, the GDP growth rate fell to -5.6% in the final quarter of 2008 due to a sudden slowdown of exports, and the annual growth rate of 2009 is predicted to be -4% by IMF on the 4th of February 2009.

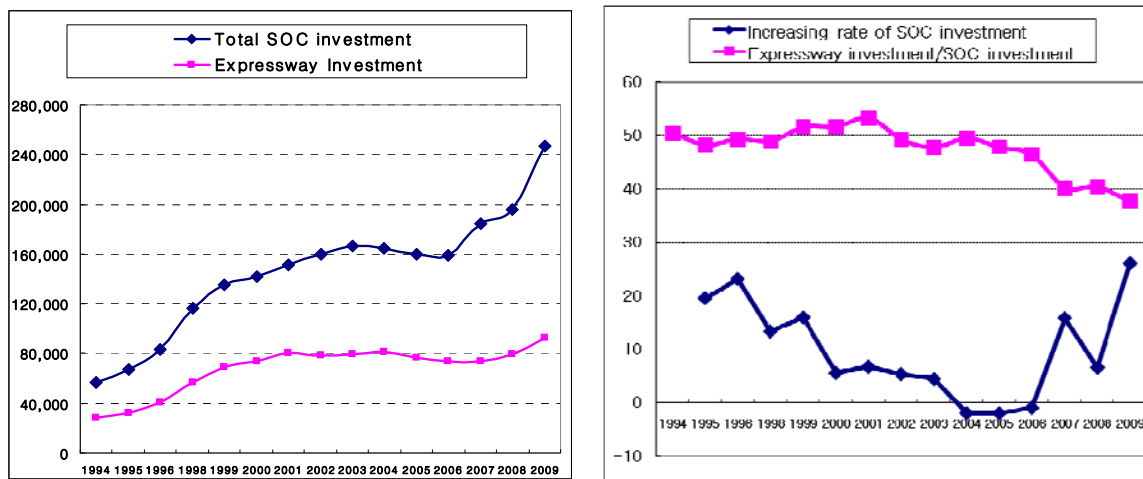


<Figure 1> The trend of economic growth rate of Korea (1971-2008)

As < Figure 1> indicates, the average growth rate of Korea is 7.8 % before the financial crisis in the year of 1997, and suffers a steep decline next year, averaging 4.4 % during 1998-2007, boosted by the sudden recovery achieved in succeeding years. And again, the GDP growth rate has been negative since the 4th quarter of 2008 owing to the global financial crisis and the considerable slowdown of export.

When uncertainty prevails all over the economic circumstances, proper counter-measures are strongly needed to get over the crisis, and increasing investment in SOC made by government is admittedly one of them. As stated in the textbook of the economics, the SOC investment expansion could be used as a pump priming policy and every government in the world has actually resorted to it. As World Bank reported, “Investment in infrastructure is key for growth and development because it expands the range of opportunities for and returns on

private investment...” (World Bank, 2008). In particular the public investment on social infrastructure (including road construction) has often been considered as an expansionary policy tool to help the economy recover from depressions.



<Figure 2> The trend of SOC and expressway investment (1994-2009)

As a token of it, the total amount of SOC investment along with the expressway one has been steadily increased. It is clearly visible in <Figure 2>. But the scale of both investments has been decreased since 2001, and kept on increasing in 2007 recovering its starting point. What are the effects of this fluctuation on Korean economy? In this paper we will bring into focus the construction or investment on the roads (roads in general/expressways) out of it.

Construction of motorways contributes an economy in two distinct ways. First, the construction itself is a production process, so it naturally increases the economy's gross domestic product (GDP). Second, it provides the economy with social infrastructure to enhance the

productivity of various sectors. The first way is a direct path to increase products and employment for the time period of the construction. We call this a “direct” effect or “production” effect. In contrast, the second way makes an "indirect" effect or “productivity” effect to the growth of the economy by increasing the productivity.

The “production” effect can be measured by an analysis of inter-industry relationship. However, in Korea, the reported input-output (IO) tables are constructed down to the "road" sector which contains the express ways and non-express ways, and no detailed table is provided for the express way sector. Recently in a joint research project initiated by the Expressway & Transportation Research Institute (ETRI, hereafter) and Korea University (KU, hereafter), Yoon, Shin and Han (2009) propose a method to decompose the "road" sector into "express way" and "non-express way" sectors using an econometric method.

The "productivity" effect of express ways can be quantified by measuring how express ways have enhanced the total factor productivity (TFP) in the total economy and in various sectors of the economy.

The present report is based on various academic works on motorways such as Bae et al (2008a), Bae et al (2008b), and Yoon et al. (2009).

The report is organized as follows. Section 2 focuses on the IO analysis which explains the direct effect, i.e., the contribution of express way construction to production and employment. Section 3 analyzes the effect of express ways on the TFP. The last section concludes.

2. Contribution to Production of Expressway Construction

As briefly put in the introduction, the construction of express ways serves enhancing production in an economy, simply because road construction is in itself a process producing goods. Naturally road construction interacts with various sectors such as chemical, machine, steel, and others. Analysis of inter-industry relation provides an effective tool to measure the total effects of an economic sector on the whole economy and other sectors.

Yoon et al. (2009) analyze seven Korean Input-Output (IO) Tables reported every five years. Especially they use the tables for 1975, 1980, ..., 2005 because the road sector is introduced in the tables in year 1975. Because of frequent changes in the list of basic sectors, they re-classify the 200 basic sectors into 42 broader sectors.

The production inducement coefficient of the road sector, which measures how much total output is induced by a 1 unit increase in the final demand of the road sector, is

1975	1980	1985	1990	1995	2000	2005
------	------	------	------	------	------	------

1.9221	1.7852	2.0271	1.8899	2.0696	1.9672	2.0440
--------	--------	--------	--------	--------	--------	--------

<Table 1> The production inducement coefficient of the road sector (1975-2005)

which means, for example, that in 2005, a 1 dollar increase in the final demand for “road” increases the total output of the economy by 2.044 dollars (Yoon, et al., 2009, Table 2-5). This production multiplier 2.0440 (in year 2005) for the road sector is higher than that for the construction sector excluding the road sector.

Of the contribution of road to the total production, some portion increases its own sector production and the rest contribute to the rest sectors. Contribution of the road sector to the other 41 sectors is in sum given as follows:

1975	1980	1985	1990	1995	2000	2005
0.9221	0.7852	1.0271	0.8899	1.0696	0.9672	1.0440

<Table 2> Contribution of the road sector to the other 41 sectors (1975-2005)

(Source: Yoon, et al., 2009, Table 2-7.) So for example, in 2005, for each dollar of final demand for “road” induces 1.0440 dollar of production in the rest 41 sectors. Again this is slightly higher than that for the non-road construction sector (1.0392).

Also the production inducement coefficient is decomposed in the value-added multiplier and the import inducement coefficient, which respectively measure the contribution to the domestic and the foreign economies. In the case of the road sector we have

1975	1980	1985	1990	1995	2000	2005
0.7514	0.8008	0.7959	0.8457	0.8857	0.8723	0.8233

<Table 3> The added-value inducement coefficient of the road sector (1975-2005)

(source: Yoon et al., 2009, Table 2-9), which means that of the 2.0440 dollars of total production induced by a one dollar demand for the road sector, 0.8233. This value is higher than that for the non-road construction sector (0.8082).

As explained in the introduction, the “express way” sector is not included in the sector list covered by the IO tables. Instead the data are available only for the “road” sector, which includes both the express way and the non-express way sectors. Yoon et al. (2009) propose a method to disintegrate the total “road” sector’s coefficients into the express way and the non-express way sectors using a random coefficient model.

The basic idea of their method is to note that the total road sector coefficient is the weighted average of the express way and non-express way sectors according to the weights of

their total inputs. Especially, they discover that the regression of the road sector production inducement coefficient on the weight of the *non-express way* input quantity provides an unbiased estimate of the express way sector's production inducement coefficient. Using this method (and under other practical assumptions), they measure the production inducement coefficient of the express way sector is on average 2.3352 for the whole period while the non-express way's coefficient is 1.9018, thus resulting in the average 1.9579 for the road sector. This means that demand for the express ways induces more production than the non-express ways.

To summarize Yoon et al.'s (2009) finding, the express way sector induces more production than the non-express way sector, and the road sector (which contains both the express way and the non-express way sectors) causes slightly more production than the non-road construction sector.

3. Impact of Express Ways on Productivity

According to the standard economic theory, advance in productivity is the main source of sustained economic growth. As already mentioned, The World Bank Report (2008) states "investment in infrastructure is key for growth and development because it expands the range of opportunities for and returns on private investment." Obviously it would not recommend increasing to road extension without limit because the amount of socially available resource is

limited. Thus we are called for a research on how much the existing roads and expressways contribute to the advance in productivity.

Measuring how expressway affects the productivity is practically important because it allows us to judge whether the extension of roads is deficient, adequate, or surplus. A relatively high contribution of expressways to enhancing productivity may be interpreted as the sign of a relatively deficient amount of existing expressway, thus issuing the signal that the construction of expressways should be promoted, and vice versa.

Yoon et al. (2009) measure the effect of expressways on productivity in Korea and for 19 OECD countries. Their analysis is important considering the debates in Korea regarding whether there are already a sufficient (and even surplus) amount of roads or more roads should be constructed. The main argument for the sufficiency of road infrastructure is supported by the fact that Korea is ranked 15th out of 28 countries in terms of the expressway capacity, and 13th out of 21 countries in terms of railway scale, which is a relatively high level of transportation infrastructure considering Korea falls into the 23rd rank among OECD countries in terms of per capita GDP (Ministry of Land, Transport and Maritime Affairs, 2001). In contrast, those who maintain that there are not enough transportation infra argue that countries with similar properties and economic status (e.g., land space, population, GDP, etc.) are to be comparable. Using this approach and data from International Road Foundation's *World Road Statistics*,

Expressway & Transportation Research Institute (2003) compares Korea of year 2003 to Spain of year 1996 when her per capita GDP (12,112 USD) was similar to then Korea's status (12,232 USD), and maintains that Korea's road extension per land coefficient (square root of population times land area) is 0.044, which is just above a half of Spain's 0.078 with a much higher number of cars per road kilometre (145 for Korea versus 52 for Spain), implying that Korea has much less road extension relative to comparable countries. Yoon et al.'s (2009) analysis would provide another (and an important) criterion (namely contribution to productivity) for judging the sufficiency of roads.

Productivity is typically defined as total factor productivity (TFP) which is the residual of the output after accounting for the contributions of labor and capital stock. Thus, loosely speaking, TFP is what is unexplained by the input factors and measures how much more the output is produced for the given amount of inputs. If express ways positively affect the productivity, then holding the input factors (labor and capital stock) constant, the extension of expressway should still increase the output. In its simplest form, $\log(\text{GDP})$ is regressed on $\log(K)$, $\log(L)$ and $\log(\text{ROAD})$, where K is capital stock, L is labor, and ROAD is the road length (or other interesting variables). Then the coefficient of $\log(\text{ROAD})$ measures how much GDP increases in percentage when ROAD increases 1 percent for fixed capital stock and labor.

Yoon et al. (2009) use panel data of 19 countries for 16 years (1990-2005). Using panel data, one can control for unobservable time-invariant individual effects which occur due to individual cultural or political factors. It is notable that the total sample size increases dramatically by using panel data and the resulting estimates are typically more accurate than using only time series or only cross-sectional variation. Also because individual fixed effects are controlled for, the risk of falsely identifying spurious relationship as the causal effect is minimized if not perfectly eliminated.

Importantly, not only expressway construction affects GDP, but there may also be reverse causality. That is, the demand for expressways can increase as GDP goes up because people want to spend more time on leisure, thus expressway length can be affected by GDP. This is a typical example of endogeneity, which makes the least squares estimators incurably biased. This endogeneity problem can be resolved by considering lagged values of road extension because of the natural flow of causality from the past to the future.

In Yoon et al.'s (2009) analysis, the panel data set is constructed from the OECD Outlook Database (for GDP, employment, and capital stock volume) and the motorway network data obtained from OECD Factbook 2008. Because of the limited data availability for capital stock and motorway network length in particular, the number of countries reduces to 19 and the

years cover the period of 1990-2006 (i.e. 17 years). Yet this data set is much more ample than the widely used STAN data.

The 19 countries include: Austria, Belgium, Canada, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Ireland, Italy, Japan, Korea, Netherlands, New Zealand, Portugal, Sweden, and United States. In the original OECD Outlook Database, capital stock is missing for Korea, and the motorway network data are available for Korea only for 1998-2005. Yoon et al. (2009) fill in the gap using Pyo's capital stock data and using the expressway length data released by Korean National Statistical Office and the Ministry of Land, Transport and Maritime Affairs. Because the data source for Korea is different from that of the other countries, one may suspect the validity of pooling the data together. But this problem does not make a big issue because country-specific fixed effects are included in the model. Any data incompatibility can be captured by individual fixed effects, and the effect of motorway length can be consistently estimated.

Because of possible dynamics in the system, a dynamic panel regression is used in Yoon et al.'s (2009) analysis. The property that the explanatory variables are only predetermined but not strictly exogenous (in the sense that past growth may affect present motorway network growth) has been accounted for by a generalized method of moments (GMM) approach to dynamic panel data estimation in their study. With all these details taken care of, Yoon et al.

conclude that a 1 percentage point increase in the per-worker motorway length *last year* results in an approximately 0.010-0.018 percentage point rise of the per-work GDP growth rate *this year*, holding past economic conditions (more specifically, last two years' growth rates, motorway length at time $t - 2$, output level at $t - 1$, together with the capital stock growth rate) constant (Table 3-5 of Yoon et al.). The long run effect is approximately 0.015-0.025.

Yoon et al. (2009) also detect that the marginal effect of additional motorway is accelerated once the existing motorway length passes through a critical point. Based on this finding, they conclude that the per-worker motorway length in Korea is relatively small so Korea may need more motorways considering its population in order to attain effectiveness. The acceleration effect should however be taken with caution only for the sample space used in the research, so one should not expect it to continue as the per-worker motorway length keeps increasing.

4. Conclusion

As explained in the introduction, investment in infrastructure is key for growth and development because it expands the range of opportunities for and returns on private investment. In Korea, the public capital, especially the road capital has played a significant role in improving economic conditions by boosting the employment, private capital and demand material inputs in every

industrial sectors. So far this study has gathered up the academic results achieved by the leading studies related to this field, and empirically proved the hypothesis that in Korea the further investment on the expressways representative of road capital has still a powerful effect and a potential role to play in the future.

References

Annes Brian A., Nicole A. Carpenter, Anita Hashmani, Benjamin J. McGinnis, Michael A. Parrish, Niles N. Joshi, and James H. Lambert (2006) "Prioritizing Highway Construction: Benefits Analysis", 2006 IEEE Systems and Information Engineering Design Symposium.

Bae I. C., and Lee C. B. (2008a), *A Study on the Measure of Increasing the Competitive Power of Korea Expressway Corporation*, ETRI

Bae I. C., and Lee C. B. (2008b), *A Study on the Road Policy Deployment in Coping with the Future Environmental Changes*, ETRI

Heavner Brat (2000), “Paving the Way – How Highway Construction Has Contributed to Sprawl in Maryland”, MaryPIRG Foundation

Lambert J. H., C. A. Pinto, and K. D. Peterson (2003) “Extended Comparison Tool for Major Highway Projects, Report VTRC 03-CR18. Charlottesville, VA: Virginia Transportation Research Council.

OECD (2000), *OECD Road Transport and Intermodal Linkages Research Programme: Outlook 2000*, OECD.

OECD (2009), Glossary on Statistical Terms. Available at <http://stats.oecd.org/glossary/>

Safirova Elena A., Sebastien Houde, and Winston Harrington (2007). “Marginal Social Cost Pricing on a Transportation Network : Comparison of Second-Best Policies”, Discussion Papers, 07-52, Resources For the Future.

Yoon, C. H., K. H. Shin, and C. Han, (2009), *A Study on the Inter-Industry Relations of Expressways and Their Effects on Economic Growth in Korea* (to be published on July)